1. A method for forming an MTJ memory cell having a substantially circular horizontal cross-section, wherein a ferromagnetic free layer in said cell has magnetic anisotropy provided by magnetic coupling with an antiferromagnetic layer comprising:

providing a substrate;

forming on said substrate a layered magnetic tunneling junction (MTJ) structure, said formation further comprising:

forming on said substrate a seed layer;

forming on said seed layer a bottom antiferromagnetic layer;

forming on said bottom antiferromagnetic layer a synthetic antiferromagnetic (SyAF) pinned layer;

forming on said pinned layer a tunneling barrier layer;

forming on said tunneling barrier layer a ferromagnetic free layer;

forming on said ferromagnetic free layer a top antiferromagnetic layer;

forming on said top antiferromagnetic layer a capping layer;

annealing said layered MTJ structure in an external magnetic field, thereby pinning said SyAF layer and magnetically coupling said top antiferromagnetic layer to said ferromagnetic free layer to produce, thereby, a magnetic anisotropy in said free layer;

patterning said layered MTJ structure to create a horizontal cross-sectional shape that is substantially circular.

2. The method of claim 1 wherein said seed layer is a layer of NiFe, NiCr, NiFeCr, Cu, Ti, Ta, Ru, Rh, TiN, TiW, W, or TaW formed to a thickness between approximately 5 and 500 angstroms.

3. The method of claim 1 wherein said bottom antiferromagnetic layer is a layer of the antiferromagnetic material IrMn, RhMn, RuMn, OsMn, FeMn, FeMnCr, FeMnRh, CrPtMn, TbCo, NiMn, PtMn or PtPdMn and it is formed to a thickness between approximately 40 and 400 angstroms.

4. The method of claim 1 wherein said SyAF pinned layer is formed by a method further comprising:

forming a first layer of ferromagnetic material on said bottom antiferromagnetic layer;

forming a coupling layer on said first ferromagnetic layer;

forming a second layer of ferromagnetic material on said coupling layer.

5. The method of claim 4 wherein said first and second ferromagnetic layers are layers of Co, Ni, Fe or their alloys or CoFeB, formed to thicknesses between approximately 5 and 100 angstroms.

6. The method of claim 4 wherein said coupling layer is a layer of Ru, formed to a thickness between approximately 7 and 8 angstroms or a layer of Rh formed to a thickness between approximately 5 and 6 angstroms.

7. The method of claim 1 wherein said tunneling barrier layer is a layer of Al_2O_3, ZrO_2, AlN, HfO_2 or multilayers thereof and said tunneling barrier layer is formed to a thickness between approximately 3 and 30 angstroms.

8. The method of claim 1 wherein said ferromagnetic free layer is a layer of Co, Ni, Fe or their alloys, CoFeB, CoZrB, CoTaB or CoHfB formed to a thickness between approximately 3 and 300 angstroms.

9. The method of claim 1 wherein said top antiferromagnetic layer is a layer of IrMn, RhMn, RuMn, OsMn, FeMn, FeMnCr, FeMnRh, CrPtMn, TbCo, NiMn, PtMn or PtPdMn and it is formed to a thickness to optimize the magnetic anisotropy of the ferromagnetic free layer.

10. The method of claim 9 wherein the top antiferromagnetic layer is a layer of IrMn, RhMn, RuMn, OsMn, FeMn, FeMnCr, FeMnRh, CrPtMn, TbCo, NiMn, PtMn or PtPdMn formed to a thickness between approximately 2 and 20 angstroms.

11. The method of claim 1 wherein said annealing comprises raising the MTJ structure to a temperature between approximately 100^0C and 400^0C for a time between approximately 0.5 and 20 hours in an external magnetic field between approximately 100 and 20,000 Oe.

12. The method of claim 1 wherein said patterning produces a circular horizontal cross-section with a diameter of approximately 1.0 microns or less.

13. The method of claim 1 wherein said substrate is a planarized layer of insulation containing therein a conducting word line and wherein said MTJ structure is formed on a lower conducting electrode situated substantially over said word line.

14. The method of claim 13 wherein a bit line is formed over said MTJ structure in a direction orthogonal to said word line.

15. An MTJ memory cell having a substantially circular horizontal cross-section, wherein a ferromagnetic free layer in said cell has a magnetic anisotropy provided by magnetic coupling with an antiferromagnetic layer comprising:

a substrate;

a layered magnetic tunneling junction (MTJ) structure, formed on said substrate, said MTJ structure comprising:

a seed layer;

a bottom antiferromagnetic layer formed on said seed layer;

a synthetic antiferromagnetic (SyAF) pinned layer formed on said bottom antiferromagnetic layer;

a tunneling barrier layer formed on said pinned layer;

a ferromagnetic free layer formed on said pinned layer;

a top antiferromagnetic layer formed on said ferromagnetic free layer;

a capping layer formed on said top antiferromagnetic layer; and

wherein said top antiferromagnetic layer is magnetically coupled to said ferromagnetic free layer to produce, thereby, a magnetic anisotropy in said free layer; and

wherein said layered MTJ structure has been patterned to create a horizontal cross-sectional shape that is substantially circular.

16. An array of MTJ memory cells having substantially circular horizontal cross-sections, wherein a ferromagnetic free layer in each such cell has a magnetic anisotropy provided by magnetic coupling with an antiferromagnetic layer and wherein each such cell is located at an orthogonal intersection of a word line and a bit line and is positioned substantially between said word line and bit line.